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DETERMINATION OF RADIOISOTOPE CONCENTRATION IN MINING SAMPLES WITH THE SIMPLE AND NEUTRON ACTIVATION ANALYSIS IN WEST TIMOR ISLAND EAST NUSA TENGGARA

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Abstract

[Determination of Radioisotope Concentration in Mining Samples with The Simple and Neutron Activation Analysis in West Timor Island East Nusa Tenggara] *The nature of Timor island have contents of several kinds of mining mineral, which still buried in rock, one of them is radioisotope that deposit activity concentration in the rock is unknown. This radioisotope is needed in several sectors as an alternative energy sources that begin to be developed in Indonesia. Problems specifications were studied in this research about activity concentration of radioisotope in the sample of mining and investigate of its prospect.*

The methods of research comprise of observe/ survey, sampling, analysis, and interpretation, which are applied in two analysis modes: 1) the simple analysis, and 2) neutron activation analysis (relative method). The steps of sample processing consist of: 1) grouping, 2) drying, 3) refining I, 4) burning, 5) refining II, 6) balancing, 7) stabilizing, and 8) drying again. The last processing results the softest dust. Furthermore procedures with the simple analysis comprise of: 1) to count sample, 2) to correct with background, 3) to calculate concentration of radioisotope element within the mine sample. The procedures for neutron activation analysis: 1) the softest dust sample is put into the polyethilene capsule and irradiated together with standard sample, then refrigerated during one week, 2) to count field and standard sample on the same time and detector is same calibrated, 3) to correct with background, 4) to calculate concentration of radioisotope element within the mine sample. The results of research: activity concentration of radioisotope deposit in mining samples at sub-district of Amarasi Kupang Wast Timor Island with simple analysis about 4.36 x 10^{-5} µCi/ gram up to 2.34 x 10^{-4} µCi/ gram, result with neutron activation analysis about 43.8 part per million or 4.38 x 10^{-5} unit up to 235.3 part per million or 2.353 x 10^{-4} unit. Activity concentration of radioisotope deposit in mining samples give estimation that radioisotope deposit in mining samples is possible prospect for exploration but still necessary another data.

Key words: *determination; concentration; radioisotope; mining*

Abstrak

Alam pulau Timor menyimpan berbagai jenis mineral tambang yang masih terpendam dalam batuan, salah satu di antaranya adalah radioisotop yang konsentrasi deposit dalam batuan belum diketahui. Rradioisotop tersebut diperlukan dalam beberapa bidang sebagai salah satu sumber energi alternatif yang sudah mulai dikembangkan di Indonesia. Spesifikasi masalah yang dikaji dalam penelitian ini menyangkut konsentrasi aktivitas radioisotop dalam sampel bahan galian dan menyelidiki keprospekannya.

Metode penelitian meliputi observasi/survei, sampling, analisis, dan interpretasi, yang diterapkan dalam dua model analisis: 1) analisis sederhana, dan 2) analisis aktivasi neutron (motode nisbi). Langkah-langkah pengolahan sampel terdiri atas: 1) pengelompokan, 2) pengeringan, 3) penghalusan I, 4) pembakaran, 5) penghalusan II, 6) penimbangan, 7) penstabilan, dan 8) pengeringan. Pengolahan akhir menghasilkan debu sangat halus.

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Prosedur selanjutnya dengan analisis sederhana meliputi: 1) mencacah sampel, 2) mengoreksi dengan cacah latar, 3) menghitung konsentrasi radioisotop dalam sampel bahan galian. Prosedur untuk analisis aktivasi neutron: 1) sampel debu sangat halus dimasukkan ke dalam kapsul polyethilena dan diiradiasi bersamaan dengan sampel standar, kemudian didinginkan selama satu minggu, 2) mencacah sampel lapangan dan sampel standar pada waktu yang sama dengan detektor yang terkalibrasi sama, 3) mengoreksi dengan cacah latar, 4) menghitung konsentrasi radioisotop dalam sampel bahan galian.
Hasil yang diperoleh: konsentrasi aktivitas deposit radioisotop dalam sampel bahan galian di Kecamatan Amarasi Kupang pulau Timor barat, berkisar antara 4,36 x 10^{-5} μCi/ gram sampai dengan 2,34 x 10^{-4} μCi/ gram (analisis sederhana), dan 43,8 ppm = 4,38 x 10^{-5} satuan sampai dengan 235,3 ppm = 2,353 x 10^{-4} satuan (analisis aktivasi neutron). Konsentrasi aktivitas deposit radioisotop dalam sampel bahan galian memberikan gambaran bahwa deposit unsur dalam bahan galian tersebut kemungkinan prospek untuk eksplorasi (masih perlu data lain).

Kata kunci: *determinasi, konsentrasi, radioisotop, tambang*

INTRODUCTION

Pre survey shows that at Sub-district of Amarasi Kupang Timor Island deposited radioisotope in mining, that its concentration is unknown[8]. Accumulation and composition of radioisotope in deposit mineral estimated was formatted or formed while formation and deformation of rocks at Timor Island (while formed of Timor island). Deformation of Timor Island was occurred on Permian and *Quarternary* time in chaos structure. Composition of rocks at Timor Island a large part dominated by *Tersier* sediment rock, and a few *methamorphyc* rock was formed by high pressure compression[2]. *Tersier* sediment rocks composed upper crystal massive surface and then left up and faulted on post-*Miosen* time by over thrust and break trust from tectonic unit then higher from north to south direction of Timor Island.

Formation Chaos of Timor Island is result of Banda Arc and Australian continental shelf collision[7]. Grunau (1953, 1957), Gageonnet at al (1958), and Audley-Charles et al (1972) purpose that a part of group rocks in Timor Island is original came from appointment on a large part of Australian continental self deformation and others from masses enclosed to upper consist of all Timor mainland[7].

The main problem investigated in this research is about concentration of radioisotope deposit in mining sample at west Timor Island that is determined with the simple analysis method and neutron activation analysis (relative method). Problem specification researched about interval of element concentration in sample and prospecting in connection with exploration necessity. The aims of research comprise of: 1) to determine range of radioisotope concentration in mining samples (deposit mineral) at sub-district of Amarasi Kupang west Timor Island, 2) to investigate prospecting of radioisotope deposit in mining samples.

Field samples in form of association have element component that their sensitive were low, in order that were necessary irradiated in order to more sensitive and can be good detected[3, 9].

Reaction was occurred on irradiation process on generally only gamma neutron reaction according to[11]:

$$ {}_{Z}^{A}X + {}_{o}^{1}n \rightarrow {}_{Z}^{A+1}Y + \gamma \quad \text{.............................}(1)$$

This reaction can be followed with alpha and beta decay. For examples:

1) $ {}_{92}^{235}U + {}_{o}^{1}n \rightarrow {}_{92}^{236}U + \gamma $

$$\Rightarrow {}_{92}^{236}U \rightarrow {}_{90}^{232} + \alpha + \text{energy...............}(2)$$

2) $ {}_{90}^{232}Th + {}_{o}^{1}n \rightarrow {}_{90}^{233}Th + \gamma $

$$\Rightarrow {}_{90}^{233}Th \rightarrow {}_{91}^{233}Pa + \beta^{-} + \text{energy}$$

$$\Rightarrow {}_{91}^{233}Pa \rightarrow {}_{92}^{233}U + \beta^{-} + \text{energy.........}(3)$$

Standard sample was used in this analysis is *Thorianite* (Th,U_4) O_2. 2 H_2O with concentration 82.5 part per million and main association elements: Ce, Fe, Ca, Mn, and Mg.

Those samples were obtained from International Standard Laboratory (ISL) KVI the Netherlands. This standard sample was analyzed from complex mineral *Clarkeite* (Th, Pb, Ca, Na, $H_2O)_2$ U_2 (O, $H_2O)_7$ with main association elements Mg, Be, Fe^3, Al, and Si, that is similarly with field samples were analyzed. On simple analysis, concentration of radioisotope deposit in mining samples was calculated according to equation[12]:

$$C = \frac{cpm}{2{,}22 \ x \ 10^6} \times \varepsilon \times \frac{1}{Y} \times \frac{1}{m} \quad ....(4)$$

Where *C*: concentration (μCi/gram), *cpm*: count per minute, *ε*: detector coefficient (0.99), m = mass (grams),and Y is other correction factors like as: sample geometry, detector geometry, distance of sample to window detector, medium effect, solid angle, and others (all of this is ignored because that were already corrected).

Radioisotope concentration in mining samples on neutron activation analysis (relative method) was calculated by equation [10].

$$C_{fs} = \frac{(cpm)_{fs}}{(cpm)_{ss}} C_{ss} \quad ....(5)$$

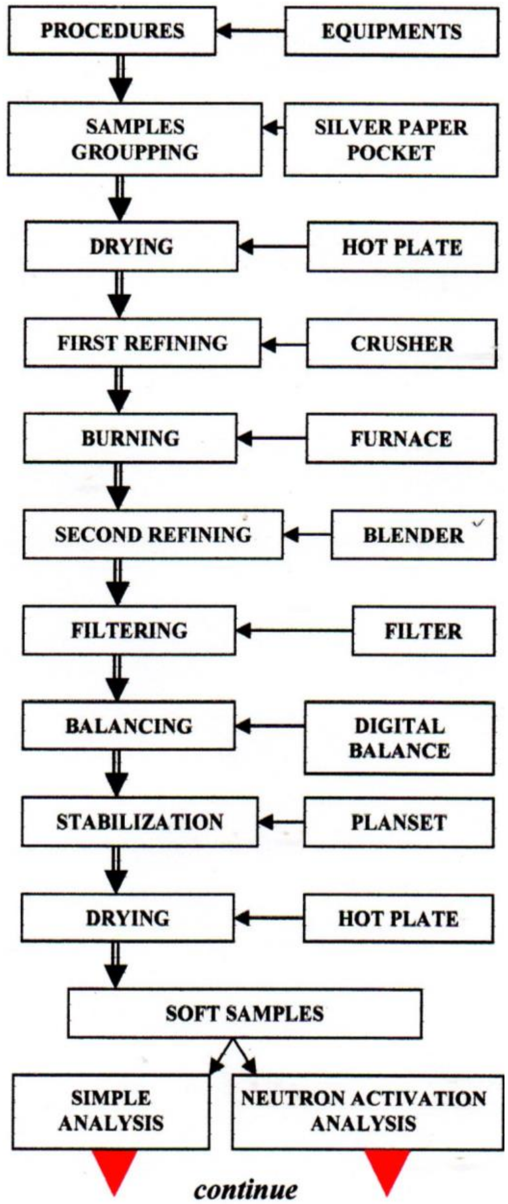
Where C_{fs}: concentration of field sample, C_{ss}: concentration of standard sample (to be known = 4.25 ppm), $(cpm)_{fs}$: counts per minute of field sample, $(cpm)_{ss}$: counts per minute standard sample. In this condition, field sample and standard sample were irradiated in the same time then cooled estimation in one week (elements are short age in sample finished disintegration (decay) and finally samples were counted in the same time with using two detector were same calibrated.

MATERIAL AND METHOD

The main equipments was used in this research among others: Reactor (irradiator) for samples irradiate, furnace for samples burning, hot plate for samples drying, crusher blender for first and second refining of samples, digital balance for samples balancing, detector for samples counting, and so on.

Methods of research consist of: observation/ surveying, sampling, irradiation, analysis, and interpretation. The all methods were applied in two analysis model: 1) simple analysis, 2) Neutron activation analysis (relative method).

Mining samples process for necessity of simple analysis and neutron activation analysis, according to procedures on Figure 1 sketch. Figure 1 sketch shows that mining samples that have been prepared, the first grouped and then were done processing continued: 1) to dry of samples, 2) to refine of samples with to crush in closed mortar, 3) to burn of samples with furnace between temperatures 400°C up to 800°C, 4) to refine of samples with blender and sift, 5) to weigh of samples with digital balance, 6) to stabilize of samples with to add enough distilled water and dry again in order that obtained samples in soft dust samples. The mining samples have been processed in form of soft dust samples continue were done simple analysis with procedures: 1) to count of samples, 2) to correct of counting result with background count, and to calculate concentration (C) of mining samples with equation (4).



Procedures for neutron activation analysis: 1) Mining sample in form of soft dust mining samples were put into *polyethilena* capsule approximately about 0.5 grams and then irradiated in reactor do together with standard sample while two hours. Neutron flux was measured for keeping of stabilization in irradiator. After irradiation, sample was cooled approximately one week, in order that element with short half live was finished decay, 2) Field and standard sample were counted in the same time and same calibration detectors, 3) The results of counting were corrected by background count, 4) Concentration of radioisotope in mining sample was calculated by equation (5).

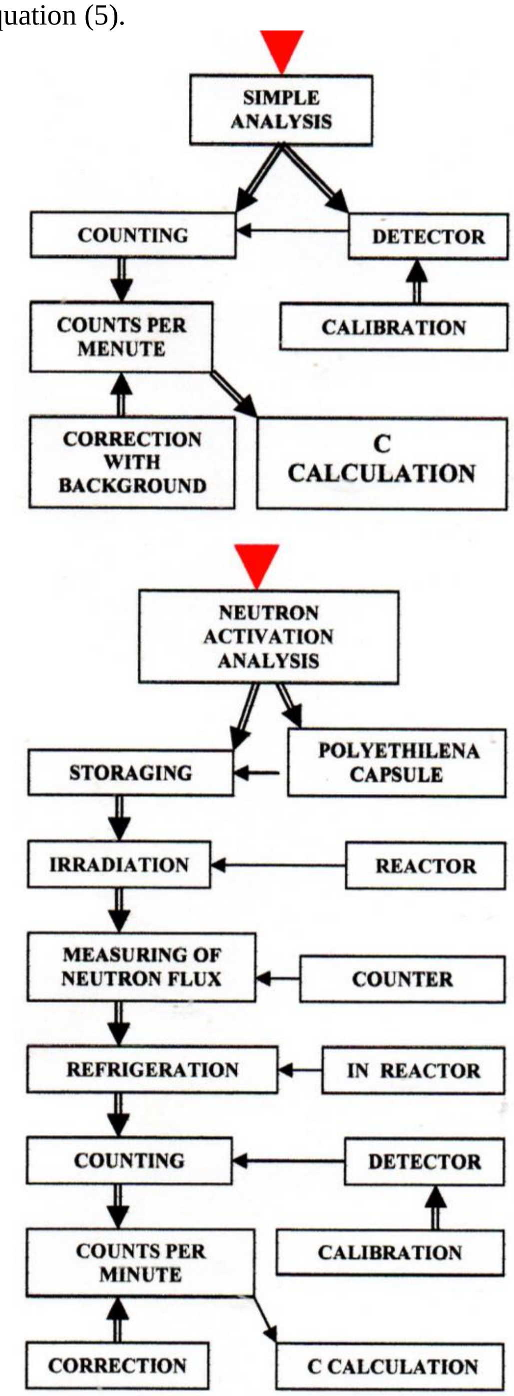


Figure 1. Systematic sketch of sample analysis determine radioisotope concentration in mining sample.

RESULT AND DISCUSSION

Figure 1 up to Figure 3 show several examples of mining samples content of

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radioisotope at Amarasi Kupang Timor Island Indonesia. Figure 5 and Figure 6 show examples of mining samples content of radioisotope in form of soft dust samples.

Figure 2a

Figure 2b

Figure 2a, 2b. Several examples of rock samples content of radioisotope.

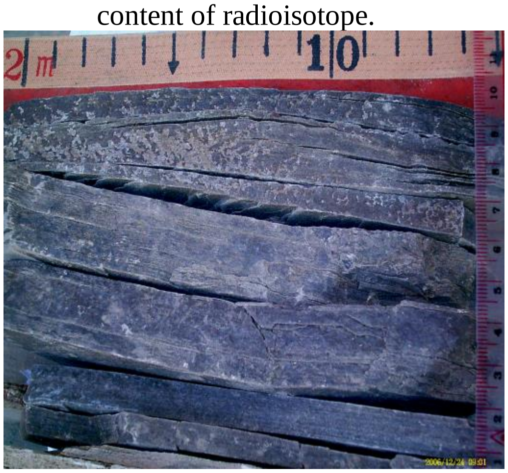

Figure 3. The example of metamorphic rock contents of radioisotope.

Figure 4. Example of coral contents of radioisotope.

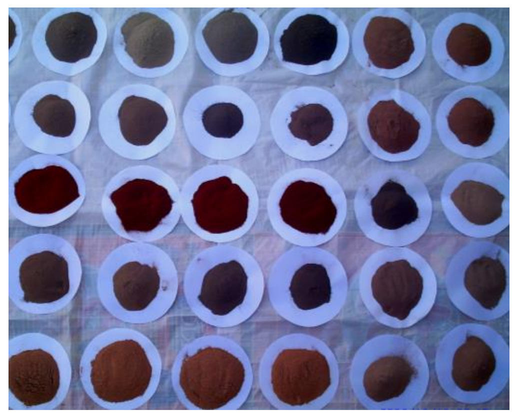

Figure 5. Example of samples content of radioisotope has been dusted.

Figure 6. The place of dust sample was detected by counter.

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Calculation results of radioisotope concentration in 50 samples of mining at Sub-district of Amarasi Kupang Timor Island Indonesia were concluded on Table 1(simple analysis) and Table 2 (neutron activation analysis).

Table 1. Measurement of radiation count, mass, and calculation results of radioisotope concentration in mining samples at Amarasi Kupang Timor Isaland Indonesia (Detector efficiency = 0,99).

Sample Code	**Mass (grams)**	**Counts per minute**	**Concentration (μCi/gram)**	**Position of Sample Taking**
Spl. 1a		38	0.56 x 10^{-6}	10º 08’
1b		35	0.52 x 10^{-6}	52.6” S
1c		46	0.68 x 10^{-6}	123º 49’
1d		43	0.64 x 10^{-6}	11.4” E
1e		41	0.61 x 10^{-6}	*Alt*: 51 m
Spl. 2a		35	0.52 x 10^{-6}	10º 10’
2b		38	0.56 x 10^{-6}	02.5” S’
2c		29	0.43 x 10^{-6}	123º 49’
2d		34	0.51 x 10^{-6}	32.7” E
2e		35	0.52 x 10^{-6}	*Alt*: 108 m
Spl. 3a		41	0.61 x 10^{-6}	10º 12’
3b		42	0.62 x 10^{-6}	56.6” S
3c		32	0.48 x 10^{-6}	123º 48’
3d		37	0.55 x 10^{-6}	37.7” E
3e		41	0.61 x 10^{-6}	*Alt*: 73 m
Spl. 4a		42	0.62 x 10^{-6}	10º 11’
4b		45	0.67 x 10^{-6}	’ 48.8” S
4c		41	0,61 x 10^{-6}	123º 48’
4d		32	0.48 x 10^{-6}	16.5” E
4e		35	0.52 x 10^{-6}	*Alt*: 108 m
Spl. 5a		66	0.98 x 10^{-6}	10º 11’
5b		63	0.94 x 10^{-6}	38.8” S
5c		71	1.06 x 10^{-6}	123º 49’
5d		68	1.01 x 10^{-6}	27.2” E
5e	30	74	1,10 x 10^{-6}	Alt: 98 m
Spl. 6a		109	1.62 x 10^{-6}	10º 10’
6b		105	1.56 x 10^{-6}	20.6” S
6c		117	1.74 x 10^{-6}	123º 48’
6d		141	2,10 x 10^{-6}	35.5” E
6e		139	2.07 x 10^{-6}	*Alt*: 76 m
Spl. 7a		42	0.62 x 10^{-6}	10º 09’
7b		54	0.80 x 10^{-6}	36.7” S
7c		46	0.68 x 10^{-6}	123º 49’
7d		47	0.70 x 10^{-6}	22.1” E
7e		53	0.79 x 10^{-6}	*Alt*: 69 m
Spl. 8a		105	1.56 x 10^{-6}	10º 10’
8b		109	1.62 x 10^{-6}	19.7” S
8c		132	1.96 x 10^{-6}	123º 48’
8d		124	1.84 x 10^{-6}	37.4” E
8e		143	2.13 x 10^{-6}	*Alt*: 70 m
Spl. 9a		129	1.92 x 10^{-6}	10º 10’
9b		129	1.92 x 10^{-6}	17.2” S
9c		122	1.81 x 10^{-6}	123º 48’
9d		116	1.72 x 10^{-6}	38.7” E
9e		131	1.95 x 10^{-6}	Alt: 65 m
Spl. 10a		118	1.75 x 10^{-6}	10º 10’
10b		122	1.81 x 10^{-6}	15.4” S
10c		114	1.69 x 10^{-6}	123º 48’
10d		116	1.72 x 10^{-6}	36.5” E
10e		115	1.71 x 10^{-6}	Alt: 62 m

Table 2. Measurement results of radiation count on standard samples, field samples, and calculation results of radioisotope concentration in 50 samples of mining at Amarasi Kupang Timor Isaland Indonesia (C_{ss} = 4.25 ppm).

Sample Code	(Cpm) Standard	(Cpm) Sample	Concentration (ppm)
Spl.1a		42	0.56
1b		39	0.52
1c		51	0.68
1d		47	0.64
1e		45	0.61
Spl.2a		39	0.52
2b		42	0.56
2c		32	0.43
2d		38	0.51
2e		39	0.52
Spl.3a		45	0.61
3b		46	0.62
3c		36	0.48
3d		41	0.55
3e		45	0.61
Spl.4a		46	0.62
4b		50	0.67
4c		45	0,61
4d		36	0.48
4e		39	0.52
Spl.5a		73	0.98
5b		70	0.94
5c		79	1.06
5d		75	1.01
5e		82	1,10
Spl.6a	315	120	1.62
6b		116	1.56
6c		129	1.74

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6d		156	2,10
6e		153	2.07
Spl.7a		46	0.62
7b		59	0.80
7c		50	0.68
7d		52	0.70
7e		59	0.79
Spl.8a		116	1.56
8b		120	1.62
8c		145	1.96
8d		136	1.84
8e		158	2.13
Spl.9a		142	1.92
9b		142	1.92
9c		134	1.81
9d		128	1.72
9e		145	1.95
Spl.10a		130	1.75
10b		134	1.81
10c		125	1.69
10d		128	1.72
10e		127	1.71

Calculation results in Table 1 and Table 2 have the similarly value. The both methods show that radioisotope concentration in 50 mining samples about 0.43 x 10^{-6} μCi/gram up to 2.13 x 10^{-6} μCi/ gram (simple analysis) or 0.43 part per million up to 2.13 part per million (Neutron Activation Analysis).

This result gives estimate that radioisotope concentration in mining samples is nearly same with the minimum value for necessity exploration. That mean radioisotope content in mining sample is not prospect for exploration, but very important for environmental mapping. For completing this purpose is necessary done another research to know others variable for exploration like as distribution wide, content volume, and so on. That is also important to take sample on depth position approximately 60 meters or more from the surface. This case can be done by drilling, and then analyze samples like as the both methods above. This method gives the exact value about the prospect of radioisotope content in mining samples, because the samples was taken in enough depth.

CONCLUSION

Based on quantitative and qualitative analysis results upon, can be proposed two conclusions:

1. Radioisotope concentration in mining samples at Sub-district of Amarasi Kupang Timor Island Indonesia about 0.43 x 10^{-6} μCi/gram up to 2.13 x 10^{-6} μCi/ gram (simple analysis) or 0.43 part per million up to 2.13 part per million (Neutron Activation Analysis).
2. Radioisotope concentration in mining samples at Sub-district of Amarasi Kupang Timor Island Indonesia is not prospect for exploration but important for environmental mapping.

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